DECLARATION

I, Tomomi Komatsu, of SHIGA INTERNATIONAL PATENT OFFICE, 3-1, Yaesu 2-chome, Chuo-ku, Tokyo, Japan, understand both English and Japanese, am the translator of the English document attached, and do hereby declare and state that the attached English document contains an accurate translation of the official certified copy of Japanese Patent Application No. 2002-314148 and that all statements made herein are true to the best of my knowledge.

Declared in Tokyo, Japan

This 9th day of January, 2007

Tomomi Komatsu

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PATENT OFFICE
JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this office.

Date of Application: October 29, 2002

Application Number: Patent Application No. 2002-314148
[JP 2002-314148]

Applicant(s): Honda Giken Kogyo Kabushiki Kaisha

Dated September 4, 2003

Commissioner, Japan Patent Office (Yasuo Imai)

No. 2003-3072594

[Title of the Document] Patent Application

[Docket Number] H102300801

[Filing Date] October 29, 2002

[Recipient] Commissioner, Japanese Patent Office

[International Classification] H01M 8/04

[Title of the Invention] FUEL CELL SYSTEM

[Number of Claims] 7

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[Docket Number]	008707

[Amount of Payment]		21000
[List of Documents Submitted]		
[Item]	Specification	1
[Item]	Drawing	1
[Item]	Abstract	1
[General Power of Attorney]		9705358
[Necessity of Proof]		Yes

Patent Application No. 2002-314148

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[Claims for the Patent]

[Claim 1]

A fuel cell system characterized by comprising:

a fuel cell which generates electric power based on hydrogen gas and an oxidant gas supplied from the outside;

a hydrogen gas supply flow path for supplying hydrogen to said fuel cell;

a hydrogen off gas circulation path for returning the hydrogen off gas from said fuel cell to said hydrogen gas supply flow path;

a hydrogen pump for boosting the hydrogen off gas mounted in said hydrogen off gas circulation path;

a hydrogen off gas bypass flow path which bypasses said hydrogen pump to return the hydrogen off gas to said hydrogen gas supply flow path;

an ejector provided in said hydrogen gas supply flow path for sending the hydrogen off gas in said hydrogen off gas bypass flow path to the hydrogen gas supply flow path.

[Claim 2]

The fuel cell system according to claim 1, characterized in that reverse flow prevention means is provided at said hydrogen off gas bypass flow path for checking back flow of the hydrogen off gas.

[Claim 3]

The fuel cell system according to claim 1 or 2, characterized in that said hydrogen off gas circulation flow path and said hydrogen off gas bypass flow path are connected to the intake side of said ejector.

[Claim 4]

The fuel cell system according to claim 2 or 3, characterized in that said reverse flow prevention means is an isolation valve, which is controlled in response to the driving state of said hydrogen pump.

[Claim 5]

The fuel cell system according to claim 4, characterized in that said isolation valve is controlled so that it is closed when the rotation speed of said hydrogen pump exceeds a predetermined rotation speed, and is controlled so that it is opened when the rotation speed of said hydrogen pump falls below a predetermined rotation speed.

[Claim 6]

The fuel cell system according to claim 2 or 3, characterized in that said reverse flow prevention means is an isolation valve, which is controlled to be a closed state when the outside temperature is above a predetermined temperature and which is controlled to be an open state when the outside temperature is below a predetermined temperature.

[Claim 7]

The fuel cell system according to claim 2 or 3, characterized in that said reverse flow prevention means is a check valve, which allows said hydrogen off gas to flow along said hydrogen off gas bypass flow path in a direction toward said ejector, and which checks the hydrogen off gas from flowing in an opposite direction.

[Title of the Invention] FUEL CELL SYSTEM

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

This invention relates to a fuel cell system for use in fuel cell vehicles and the like.

[0002]

[Conventional Art]

Because fuel cells which generate power by using hydrogen gas and an oxidizing gas as reaction gases produce water as well as power, an even larger consumption amount of hydrogen gas and oxidizing gas than is necessary for power generation is supplied in order to discharge this produced water from inside the fuel cell.

Accordingly, there is non-reacted hydrogen gas contained in the anode off gas discharged from the anode of the fuel cell (hereunder referred to as hydrogen off gas), and since this is emitted in this state, fuel consumption deteriorates. Therefore, in order to improve fuel consumption, a fuel cell

system has been devised in which this hydrogen off gas is positively circulated using a device for raising the pressure, such as a hydrogen pump or the like, and mixed with fresh hydrogen gas and again supplied to the fuel cell (for example, see Patent Document 1). Hereunder, a fuel cell system that circulates and reuses fuel in this way will be referred to as a circulation-type fuel cell system.

[0003]

However, in the case of a solid polymer electrolyte membrane-type fuel cell, because the electrolytic conductivity is reduced and the power output decreases when the solid polymer electrolyte membrane dries out, it is necessary to maintain the solid polymer electrolyte membrane at a predetermined moistness in order to maintain a favorable power generating performance. Therefore, in solid polymer electrolyte membrane-type fuel cells, there are cases in which moistened hydrogen gas is supplied to the fuel cell (for example, see Patent Document 2).

In the case of this fuel cell, the hydrogen off gas discharged from the fuel cell also contains moisture. Because of that, in the circulation-type fuel cell system provided with this solid polymer electrolyte membrane-type fuel cell, the hydrogen off gas containing moisture is circulated by the hydrogen pump or the like.

[0004]

[Patent Document 1]

Japanese Unexamined Patent Application, First Publication No. S58-30075

[Patent Document 2]

Japanese Unexamined Patent Application, First Publication No. H07-240220

[0005]

[Problems to be Solved by the Invention]

However, in the above circulation-type fuel cell system provided with this solid polymer electrolyte membrane-type fuel cell, there is concern that when the fuel cell system is stopped in a below-freezing environment, water content within the hydrogen pump freezes, so that it becomes difficult to start the hydrogen pump, and the discharge amount is reduced. When this happens, the amount of circulating hydrogen off gas is reduced when starting up at low temperatures, and as a result, there is concern that the amount of hydrogen supplied to the fuel cell is reduced, thus making stabilized startup of the fuel cell system difficult.

Furthermore, freezing of the hydrogen pump is not limited to the case where moistened hydrogen gas is supplied to the fuel cell, and may also occur in a circulation-type fuel cell system which does not actively moisten the hydrogen gas supplied to the fuel cell. That is because water is produced as well as power in fuel cells similar to the above, and this produced water is discharged together with the hydrogen off gas.

Also, in the case where the hydrogen pump is unable to drive for reasons other than freezing, and the discharge amount is reduced, the same difficulties arise.

[0006]

This invention provides a fuel cell system with excellent startup performance at low temperatures, in which hydrogen off gas can be circulated even when the hydrogen pump is unable to drive due to freezing and so on.

[0007]

[Means for Solving the Problems]

To solve the aforementioned problems, the invention according to claim 1 is a fuel cell system characterized by comprising: a fuel cell (for example the fuel cell 1 in the later mentioned embodiment) which is supplied with hydrogen gas and an oxidizing gas to generate power; a hydrogen gas supply flow path (for example the hydrogen gas supply flow path 10 in the later mentioned embodiment) which supplies hydrogen gas to the fuel cell; a hydrogen off gas circulation path (for example the hydrogen off gas circulation path 20 in the later mentioned embodiment) which returns hydrogen off gas discharged from the fuel cell to the hydrogen gas supply flow path; a hydrogen pump (for example the hydrogen pump 7 in the later mentioned embodiment) provided in the hydrogen off gas circulation path to raise the pressure of the hydrogen off gas; a hydrogen off gas bypass flow path (for example the hydrogen off gas bypass flow path 22 in the later mentioned embodiment) which bypasses the hydrogen pump to return the

hydrogen off gas to the hydrogen gas supply flow path; and an ejector (for example the ejector 6 in the later mentioned embodiment) provided in the hydrogen gas supply flow path which feeds hydrogen off gas from the hydrogen off gas bypass flow path to the hydrogen gas supply flow path.

By having such a construction, when the hydrogen pump is driving normally, the hydrogen off gas can be returned to the hydrogen gas supply flow path via the hydrogen off gas circulation path. Moreover, when the amount of circulating hydrogen off gas flowing through the hydrogen off gas circulation path is insufficient due to malfunctioning and so on of the hydrogen pump, the hydrogen off gas can be returned to the hydrogen gas supply flow path via the hydrogen off gas bypass flow path, by the ejector. Therefore the hydrogen off gas can be reliably circulated.

[0008]

The invention according to claim 2 is characterized in that, in the invention according to claim 1, reverse flow prevention means (for example the isolation valve 23, or check valve 24 in the later mentioned embodiments) is provided in the hydrogen off gas bypass flow path to prevent reverse flow of the hydrogen off gas.

By having such a construction, when the hydrogen pump is driving normally, the hydrogen off gas which has been raised in pressure by the hydrogen pump can be prevented from flowing through the hydrogen off gas bypass flow path, and the full amount of hydrogen off gas can be circulated.

[0009]

The invention according to claim 3 is characterized in that, in the invention according to claim 1 or 2, the hydrogen off gas circulation path and the hydrogen off gas bypass flow path are connected to a suction side of the ejector.

By having such a construction, it becomes possible to simplify the flow path construction.

[0010]

The invention according to claim 4 is characterized in that, in the invention according to claim 2 or 3, the reverse flow prevention means is an isolation valve (for example the isolation valve 23 in the later mentioned embodiment) which is controlled depending on a driving state of the hydrogen pump.

By having such a construction, by controlling the isolation valve to a closed state when the hydrogen pump is being driven normally, the hydrogen off gas is prevented from flowing through the hydrogen off gas bypass flow path, so that the full amount of hydrogen off gas can be circulated by the hydrogen pump, and by controlling the isolation valve to an open state when the hydrogen pump is malfunctioning or disabled, the hydrogen off gas can be circulated via the hydrogen off gas bypass flow path and the ejector.

[0011]

The invention according to claim 5 is characterized in that, in the invention according to claim 4, the isolation valve is controlled to a closed state when a rotation speed

of the hydrogen pump exceeds a predetermined rotation speed, and is controlled to an open state when the rotation speed of the hydrogen pump is lower than the predetermined rotation speed.

By having such a construction, by determining that the hydrogen pump is driving normally when the rotation speed of the hydrogen pump exceeds the predetermined rotation speed, and controlling the isolation valve to a closed state, the hydrogen off gas is prevented from flowing through the hydrogen off gas bypass flow path, so that the full amount of hydrogen off gas can be circulated by the hydrogen pump. Also, by determining that the hydrogen pump is malfunctioning or disabled when the rotation speed of the hydrogen pump is lower than the predetermined rotation speed, and controlling the isolation valve to an open state, the hydrogen off gas can be circulated via the hydrogen off gas bypass flow path and the ejector.

[0012]

The invention according to claim 6 is characterized in that, in the invention according to claim 2 or 3, the reverse flow prevention means is an isolation valve which is controlled to a closed state when an outside air temperature exceeds a predetermined temperature, and is controlled to an open state when the outside air temperature is lower than the predetermined temperature.

By having such a construction, because there is no concern that the hydrogen pump is freezing when the outside air

temperature exceeds the predetermined temperature, by controlling the isolation valve to a closed state at this time, the hydrogen off gas is prevented from flowing through the hydrogen off gas bypass flow path, thus enabling the full amount of hydrogen off gas to be circulated by the hydrogen pump. Also, because there is concern that the hydrogen pump may freeze when the outside air temperature is lower than the predetermined temperature, by controlling the isolation valve to an open state at this time, the hydrogen off gas can be circulated via the hydrogen off gas bypass flow path and the ejector.

[0013]

The invention according to claim 7 is characterized in that, in the invention according to claim 2 or 3, the reverse flow prevention means is a check valve (for example the check valve 24 in the later mentioned embodiment) which allows the hydrogen off gas to flow along the hydrogen off gas bypass flow path in a direction flowing into the ejector, and prevents flow in the reverse direction thereof.

By having such a construction, because the check valve opens and closes by mechanically sensing an increase in the pathway obstruction and suction resistance, when the hydrogen pump is being driven normally, with no electric control, the hydrogen off gas is prevented from flowing through the hydrogen off gas bypass flow path, enabling the full amount of hydrogen off gas to be circulated by the hydrogen pump. Moreover, when the amount of circulating hydrogen off gas flowing through

the hydrogen off gas circulation path due to the hydrogen pump malfunctioning (including being disabled) is insufficient, the hydrogen off gas can be circulated via the hydrogen off gas bypass flow path and the ejector.

[0014]

[Embodiments of the Invention]

Hereunder, embodiments of a fuel cell system according to the present invention will be described with reference to Figure 1 through Figure 3. Here, each of the embodiments described below is an aspect of a fuel cell system for installation in fuel cell vehicles.

[0015]

[First Embodiment]

Initially, a first embodiment of a fuel cell system according to this invention will be described with reference to Figure 1.

Figure 1 is a schematic block diagram of a fuel cell system according to the first embodiment.

A fuel cell 1 is made from a stack comprising multiple laminated cells, formed by inserting a solid polymer electrolyte membrane, made for example from a solid polymer ion exchange membrane, in between an anode and a cathode. When hydrogen gas is supplied to the anode as fuel, and air containing oxygen is supplied to the cathode as an oxidizing agent, the hydrogen ions generated by a catalytic reaction at the anode migrate to the cathode via the solid polymer electrolyte membrane, to generate power by causing an electrochemical

reaction with the oxygen at the cathode, and water is produced. Furthermore, because part of the water produced on the cathode side diffuses back to the anode side via the solid polymer electrolyte membrane, there is also water produced on the anode side.

[0016]

The air is raised to a predetermined pressure by a compressor 2, and supplied to the cathode of the fuel cell 1. After this air has been used to generate power, it is discharged from the cathode of the fuel cell 1 as air discharge gas, and discharged via a pressure control valve 3.

On the other hand, the hydrogen gas supplied from a high pressure hydrogen tank 4 passes along a hydrogen gas supply flow path 10 provided with a pressure control valve 5 and an ejector 6, and is supplied to the anode of the fuel cell 1 having been reduced to a predetermined pressure by the pressure control valve 5.

[0017]

After the hydrogen gas supplied to the fuel cell 1 has been used to generate power, non-reacted hydrogen gas is discharged from the anode of the fuel cell 1 as hydrogen off gas into a hydrogen off gas circulation path 20. The hydrogen off gas circulation path 20 is connected to a suction side of the ejector 6, and a hydrogen pump 7 and a check valve 21 are provided partway along the hydrogen off gas circulation path 20. The hydrogen pump 7 raises the pressure of the hydrogen off gas discharged from the cathode of the fuel cell

1, so that this flows into the ejector 6 through the check valve 21. As a result, the hydrogen off gas is mixed with fresh hydrogen gas supplied from the high pressure hydrogen tank 4 so as to be supplied to the anode of the fuel cell 1 a second time.

Also, a hydrogen off gas bypass flow path 22 that bypasses the hydrogen pump 7 and the check valve 21 is connected to the hydrogen off gas circulation path 20.

[0018]

In a fuel cell system constructed in this way, when the hydrogen pump 7 is driving normally, as described above, the hydrogen off gas discharged from the anode of the fuel cell 1 is raised in pressure by the hydrogen pump 7 partway along the hydrogen off gas circulation path 20, flows into the ejector 6 through the check valve 21, and is mixed with fresh hydrogen gas supplied from the high pressure hydrogen tank 4 so as to be supplied to the anode of the fuel cell 1 a second time via the hydrogen gas supply flow path 10. This is the circulation path of the hydrogen off gas when the hydrogen pump 7 is driving normally, and hereunder this path will be referred to as a "normal circulation path".

[0019]

However, when the hydrogen pump 7 cannot drive due to freezing and the like, and when even if the hydrogen pump 7 is driving, the amount of hydrogen off gas flowing by means of the normal circulation path is very low, the hydrogen off gas within the hydrogen off gas circulation path 20 in the

vicinity of the ejector 6 is drawn in by the negative pressure created when the fresh hydrogen gas delivered from the high pressure hydrogen tank 4 flows through the ejector 6. As a result, the hydrogen off gas discharged from the anode of the fuel cell 1 into the hydrogen off gas circulation path 20 passes along the hydrogen off gas bypass flow path 22 and then passes along the hydrogen off gas circulation path 20 downstream from the check valve 21, and is drawn in to the ejector 6 and mixed with fresh hydrogen gas supplied from the high pressure hydrogen tank 4, so as to be supplied to the anode of the fuel cell 1 a second time through the hydrogen gas supply flow path 10. Hereunder this path will be referred to as an "abnormal circulation path". At this time, the ejector 6 feeds the hydrogen off gas from the hydrogen off gas bypass flow path 22 into the hydrogen gas supply flow path 6.

[0020]

Accordingly, even when the hydrogen pump 7 is unable to drive due to freezing and there is a reduced amount of flow, or when the hydrogen pump 7 is malfunctioning due to reasons other than freezing, or when even if the hydrogen pump 7 is able to drive normally, the flow path in the vicinity of the check valve 21 and the hydrogen pump 7 is blocked, and so on, the hydrogen off gas can be reliably circulated at a predetermined flow rate. As a result, even in these kinds of situations, the hydrogen can be supplied to the fuel cell 1 in a stabilized condition, and the fuel cell system can be driven in a stabilized condition.

In particular, because the fuel cell system can be driven in a stabilized condition when starting up at low temperatures, the startup performance of the fuel cell vehicle is improved, thereby increasing convenience.

[0021]

In this embodiment, the part of the hydrogen off gas circulation path 20 which connects the check valve 21 and the ejector 6 can be considered as part of the hydrogen off gas bypass flow path 22, because hydrogen off gas flows therethrough at abnormal times. Hence it can be said that the hydrogen off gas circulation path 20 and the hydrogen off gas bypass flow path 22 are connected to the suction side of the ejector 6. As a result, the construction of the flow path can be simplified, and the fuel cell system can be made small and lightweight.

[0022]

However, depending on the flow path resistance of the hydrogen gas bypass flow path 22, when the hydrogen off gas is circulating through the normal circulation path, a part of the hydrogen off gas which the hydrogen pump 7 has raised in pressure passes through the hydrogen off gas bypass flow path 22 to return to the suction side of the hydrogen pump 7, without flowing towards the hydrogen gas supply flow path 10. When this happens, there is concern that it may become impossible to circulate the hydrogen off gas at the desired flow rate.

Accordingly, it is preferable to provide reverse flow prevention means in the hydrogen off gas bypass flow path 22, which prevents the hydrogen off gas which the hydrogen pump 7 has raised in pressure at normal times from passing through the hydrogen off gas bypass flow path 22 to return to the suction side of the hydrogen pump 7.

The embodiments described hereunder have reverse flow prevention means provided in the hydrogen off gas bypass flow path 22.

[0023]

[Second Embodiment]

Next, a second embodiment of a fuel cell system according to this invention will be described with reference to Figure 2. The only point in which the fuel cell system of the second embodiment differs from that of the first embodiment is that an isolation valve 23 is provided in the hydrogen off gas bypass flow path 22 as reverse flow prevention means.

Other construction is the same as the first embodiment, and hence similar parts are denoted by the same reference symbols, and description is omitted.

[0024]

Opening and closing of the isolation valve 23 is controlled by an electrical control unit (ECU) 50.

It is possible to control the isolation valve 23 depending on the driving state of the hydrogen pump 7. As one example of control in such a situation, the rotation speed of the hydrogen pump 7 is detected by a pump rotation speed sensor

51, and when the detected pump rotation speed exceeds a predetermined rotation speed N, it is determined that the hydrogen pump 7 is driving normally, and the isolation valve 23 is controlled to a closed state, while when the pump rotation speed is less than the predetermined rotation speed N, it is determined that the hydrogen pump 7 is malfunctioning, and the isolation valve 23 is controlled to an open state.

[0025]

When the isolation valve 23 is controlled in this way, if the hydrogen pump 7 is driving normally, the isolation valve 23 can be closed, so that the hydrogen off gas can be prevented from flowing along the hydrogen off gas bypass flow path 22, and the full amount of hydrogen off gas can be circulated by the hydrogen pump 7. Also, when the drive of the hydrogen pump 7 is malfunctioning (including being disabled) the isolation valve 23 can be opened, so that the hydrogen off gas can be circulated via the hydrogen off gas bypass flow path 22 and the ejector 6.

Accordingly, it becomes possible for the hydrogen to be more stably supplied to the fuel cell 1, so that the fuel cell system is again stabilized to enable driving.

[0026]

Furthermore, it is also possible to control the isolation valve 23 depending on the outside air temperature. As one example of control in such a situation, when the outside air temperature detected by an outside air temperature sensor 52 exceeds a predetermined temperature T, it is determined that

the hydrogen pump 7 is driving normally without the hydrogen pump 7 freezing, and the isolation valve 23 is controlled to a closed state, while when the outside air temperature is lower than the predetermined temperature T, it is determined that there is a likelihood that the hydrogen pump 7 is freezing, and the isolation valve 23 is controlled to an open state.

[0027]

When the isolation valve 23 is controlled in this way, if there is no likelihood that the hydrogen pump 7 is freezing due to the outside air temperature exceeding the predetermined temperature, the isolation valve 23 can be closed, so that the hydrogen off gas can be prevented from flowing along the hydrogen off gas bypass flow path 22, and the full amount of hydrogen off gas can be circulated by the hydrogen pump 7. Also, when there is concern that the hydrogen pump 7 is freezing due to the outside air temperature being lower than the predetermined temperature, the isolation valve 23 can be opened, so that the hydrogen off gas can be circulated via the hydrogen off gas bypass flow path 22 and the ejector 6.

Accordingly, it becomes possible for the hydrogen to be more stably supplied to the fuel cell 1, and the fuel cell system is again stabilized to enable driving. This embodiment particularly improves the startup performance of the fuel cell system at low temperatures.

[0028]

Also, in the second embodiment, because the hydrogen off gas bypass flow path 22 is provided so as to bypass the check

valve 21, when the hydrogen off gas flows through the circulation path at abnormal times, it can flow into the ejector 6 without passing through the check valve 21. As a result, the pressure drop on the suction side of the ejector 6 can be reduced enabling an increase in the amount of hydrogen off gas being circulated.

[0029]

[Third Embodiment]

Next, a third embodiment of a fuel cell system according to this invention will be described with reference to Figure 3. The only point in which the fuel cell system of the third embodiment differs from that of the first embodiment is that a check valve 24 is provided in the hydrogen off gas bypass flow path 22 as reverse flow prevention means. For this check valve 24 it is possible to use various types of valves such as a reed valve or a poppet valve.

Other construction is the same as the first embodiment, and hence similar parts are denoted by the same reference symbols, and description is omitted.

[0030]

This check valve 24 allows the hydrogen off gas to flow along the hydrogen off gas bypass flow path 22, from the hydrogen off gas circulation path 20 downstream from the hydrogen pump 7 to the hydrogen off gas circulation path 20 upstream from the check valve 21, and prevents the hydrogen off gas from flowing along the hydrogen off gas bypass flow path 22 in the reverse direction thereof. In other words, the check valve

24 allows the hydrogen off gas to flow along the hydrogen off gas bypass flow path 22 in a direction flowing into the ejector 6, and prevents flow in the reverse direction thereof.

[0031]

When the check valve 24 is provided in the hydrogen off gas bypass flow path 22 in this way, because the check valve 24 opens and closes by mechanically sensing an increase in pathway obstruction and suction resistance, there is no electric control as in the second embodiment, and when the hydrogen pump 7 is driving normally, the check valve 24 is able to prevent the hydrogen off gas from flowing in reverse along the hydrogen off gas bypass flow path 22, so that the full amount of hydrogen off gas can be circulated by the hydrogen pump 7. Also, when the amount of hydrogen off gas circulating through the circulation path at normal times is insufficient due to drive malfunction of the hydrogen pump 7 (including being disabled), the hydrogen off gas can be circulated via the hydrogen off gas bypass flow path 22, the check valve 24, and the ejector 6.

Accordingly, it becomes possible for the hydrogen to be more stably supplied to the fuel cell 1, and the fuel cell system is again stabilized to enable driving. Also, electric control becomes unnecessary, enabling the construction of the fuel cell system to be simplified.

[0032]

Moreover in the third embodiment, in the same way as in the second embodiment, because the hydrogen off gas bypass

flow path 22 is provided so as to bypass the check valve 21, the pressure drop on the suction side of the ejector 6 can be reduced, and the amount of hydrogen off gas being circulated can be increased.

[0033]

The case in which the check valve 24 freezes is also considered. However because the downstream side of the check valve 24 is connected to the suction side of the ejector 6, a negative pressure is created on the downstream side of the check valve 24. As a result a differential pressure is created on the front and rear of the check valve 24, and due to this differential pressure the adhesion caused by freezing of the check valve 24 can be released.

[0034]

[Other Embodiments]

This invention is not limited to the above embodiments.

For example, in each of the above embodiments, in order to simplify the flow path construction and so on, the hydrogen off gas bypass flow path 22 is connected to the suction side of the ejector 6 by merging with the hydrogen off gas circulation path 20, but it is also possible to connect just the hydrogen off gas bypass flow path 22 to the suction side of the ejector 6, and to connect the hydrogen off gas circulation path 20 to the hydrogen gas supply flow path 10 further downstream from the ejector 6. In this case, it is preferable to provide an electric control type isolation valve in the hydrogen off gas bypass flow path 22 in the same way as in the second

embodiment, so that the hydrogen off gas does not flow along the hydrogen off gas bypass flow path 22 at normal times.

[0035]

[Advantages of the Invention]

As described above, according to the invention according to claim 1, when the hydrogen pump is driving normally, the hydrogen off gas can be returned to the hydrogen gas supply flow path via the hydrogen off gas circulation path, and when the amount of circulating hydrogen off gas flowing through the hydrogen off gas circulation path is insufficient due to malfunctioning and so on of the hydrogen pump, the hydrogen off gas can be returned to the hydrogen gas supply flow path via the hydrogen off gas bypass flow path, by the ejector, and the hydrogen off gas can be reliably circulated. Accordingly, when the hydrogen pump is disabled or malfunctioning, it becomes possible for the hydrogen to be stably supplied to the fuel cell, so that the superior effect of the drive of the fuel cell system being stabilized can be demonstrated.

[0036]

According to the invention according to claim 2, when the hydrogen pump is driving normally, the hydrogen off gas which has been raised in pressure by the hydrogen pump can be prevented from flowing through the hydrogen off gas bypass flow path, and the full amount of hydrogen off gas can be circulated, so that there is the effect that the fuel cell can be driven stabilized to a desired output.

According to the invention according to claim 3, it becomes possible to simplify the flow path construction, and there is the effect that a reduction in the size and weight of the fuel cell system can be achieved.

[0037]

According to the invention according to claim 4, by controlling the isolation valve to a closed state when the hydrogen pump is being driven normally, the hydrogen off gas is prevented from flowing through the hydrogen off gas bypass flow path, with the effect that the full amount of hydrogen off gas can be circulated by the hydrogen pump, and by controlling the isolation valve to an open state when the hydrogen pump is malfunctioning or disabled, there is the effect that the hydrogen off gas can be circulated via the hydrogen off gas bypass flow path and the ejector.

[0038]

According to the invention according to claim 5, by determining that the hydrogen pump is driving normally when the rotation speed of the hydrogen pump exceeds the predetermined rotation speed, and controlling the isolation valve to a closed state, the hydrogen off gas is prevented from flowing through the hydrogen off gas bypass flow path, with the effect that the full amount of hydrogen off gas can be circulated by the hydrogen pump. Also, by determining that the hydrogen pump is malfunctioning or disabled when the rotation speed of the hydrogen pump is lower than the predetermined rotation speed, and controlling the isolation

valve to an open state, there is the effect that the hydrogen off gas can be circulated via the hydrogen off gas bypass flow path and the ejector.

[0039]

According to the invention according to claim 6, because there is no concern that the hydrogen pump is freezing when the outside air temperature exceeds the predetermined temperature, by controlling the isolation valve to a closed state at this time, the hydrogen off gas is prevented from flowing through the hydrogen off gas bypass flow path, thus enabling the full amount of hydrogen off gas to be circulated by the hydrogen pump. Also, because there is concern that the hydrogen pump may freeze when the outside air temperature is lower than the predetermined temperature, by controlling the isolation valve to an open state at this time, the hydrogen off gas can be circulated via the hydrogen off gas bypass flow path and the ejector. As a result, even when the hydrogen pump is malfunctioning or disabled due to freezing, hydrogen can be stably supplied to the fuel cell, and there is the effect that the startup performance of the fuel cell system at low temperatures is improved and stabilized.

[0040]

According to the invention according to claim 7, because the check valve opens and closes by mechanically sensing an increase in the pathway obstruction and suction resistance, when the hydrogen pump is being driven normally, with no electric control, the hydrogen off gas is prevented from

flowing through the hydrogen off gas bypass flow path, enabling the full amount of hydrogen off gas to be circulated by the hydrogen pump. Moreover, when the amount of circulating hydrogen off gas flowing through the hydrogen off gas circulation path due to the hydrogen pump malfunctioning (including being disabled) is insufficient, the hydrogen off gas can be circulated via the hydrogen off gas bypass flow path and the ejector. Therefore there is the effect that construction of the fuel cell system can be simplified.

[Brief Description of the Drawings]

[Figure 1]

A schematic diagram of a first embodiment of a fuel cell system according to this invention.

[Figure 2]

A schematic diagram of a second embodiment of a fuel cell system according to this invention.

[Figure 3]

A schematic diagram of a third embodiment of a fuel cell system according to this invention.

[Description of Symbols]

1 FUEL CELL

6 EJECTOR

7 HYDROGEN PUMP

10 HYDROGEN GAS SUPPLY FLOW PATH

20 HYDROGEN OFF GAS CIRCULATION PATH

22 HYDROGEN OFF GAS BYPASS FLOW PATH

23 ISOLATION VALVE (REVERSE FLOW PREVENTION MEANS)

24 CHECK VALVE (REVERSE FLOW PREVENTION MEANS)

[Abstract]
[Problem to be Solved]

To improve the starting capability of a fuel cell system at low temperatures.

[Solution]

The fuel cell system comprises a fuel cell 1 which generates electric power based on hydrogen gas and an oxidant gas supplied from the outside, a hydrogen gas supply flow path 10 for supplying hydrogen gas to the fuel cell 1, a hydrogen off gas circulation path 20 for returning the hydrogen off gas from the fuel cell 1 to the hydrogen gas supply flow path 10, a hydrogen pump 7 for boosting the hydrogen off gas mounted in the hydrogen gas off gas circulation path 20, a hydrogen off gas bypass flow path 22 which bypasses the hydrogen pump 7 to return the hydrogen off gas to the hydrogen gas supply flow path 10, an ejector 6 provided in the hydrogen gas supply flow path 10 for sending the hydrogen off gas in the hydrogen off gas bypass flow path 20 to the hydrogen gas supply flow path 10.

[Selected Drawing] Figure 1

FIG. 1

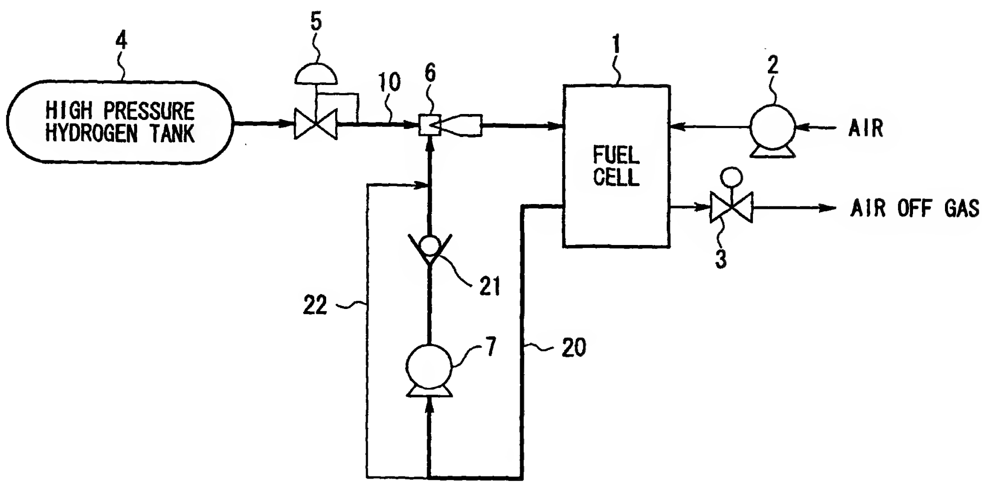
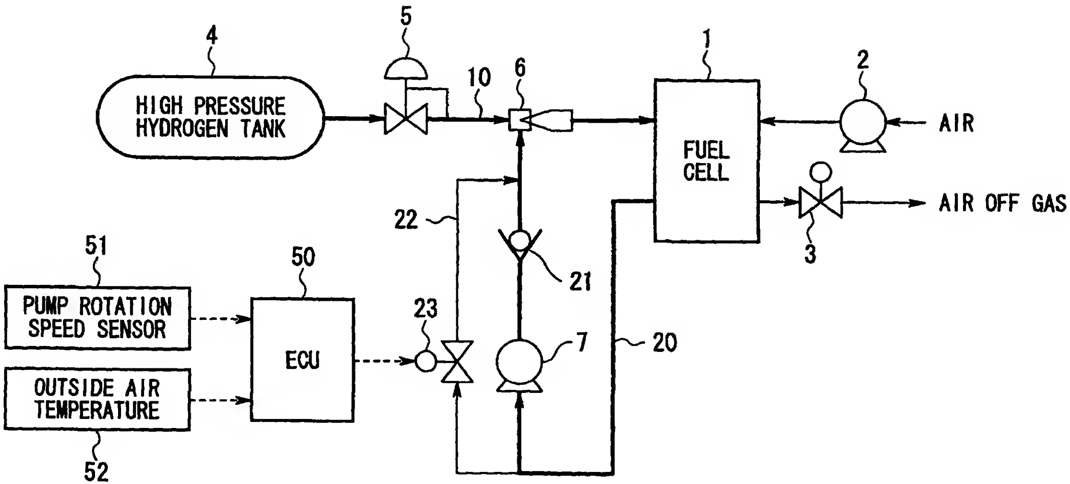
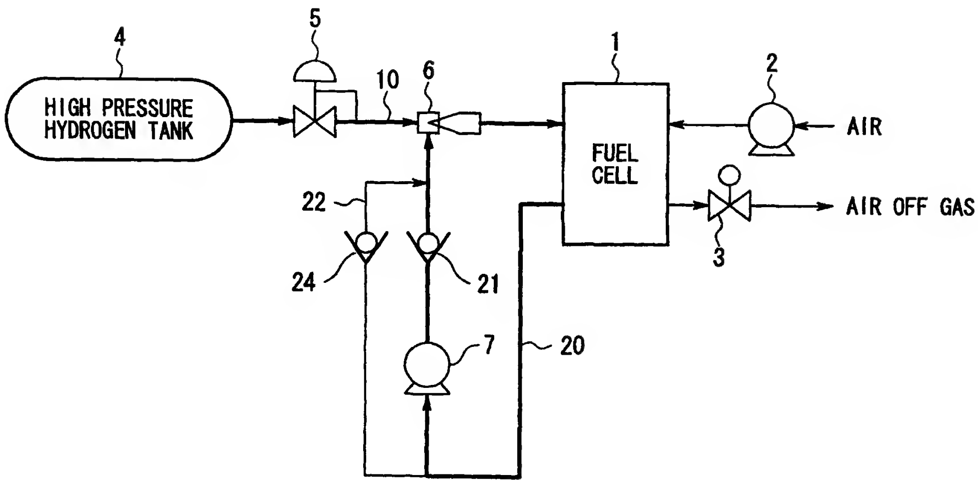

4
HIGH PRESSURE
HYDROGEN TANK
5
10
6
1
FUEL
CELL
2
AIR
3
AIR OFF GAS
21
22
7
20

FIG. 2



HIGH PRESSURE HYDROGEN TANK
FUEL CELL
AIR
AIR OFF GAS
PUMP ROTATION SPEED SENSOR
OUTSIDE AIR TEMPERATURE
ECU
1
2
3
4
5
6
7
10
20
21
22
23
50
51
52

FIG. 3


4
HIGH PRESSURE
HYDROGEN TANK
5
10
6
1
FUEL
CELL
2
AIR
AIR OFF GAS
3
22
24
21
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